University of Alberta

Design Meets Opportunity:
A Customizable Digital Approach to Design for Disability

by

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Abstract

Design for physical disability has largely focused on the functional requirements of devices; the engineers and clinicians developing these artifacts are trained to ensure proper fit and function and not necessarily trained to consider form and fashion. Traditional production methods and the economics associated with the development of these devices limits the exploration of alternatives that address both functional and emotional considerations. Other members of society often perceive a prosthetic leg, prosthetic eye or a hearing aid as the defining characteristic of the wearer, while the wearer has little opportunity to communicate self-expression through the device. The opportunity to transform these devices into expressions of personal style is enabled by employing a customizable digital process utilizing surface scanning, computer-aided design and rapid prototyping. Designs using this process will be presented to challenge the current visual language of disability while hoping to engage and encourage designers to enter the conversation of design for disability.

Preface

Ben King has worked as an industrial designer in health care with iRSM (the Institute for Reconstructive Sciences in Medicine) since early 2007. This relationship was first established through a student practicum in 2005 under the supervision of industrial design professors Robert Lederer, Steve Bell and anaplastologist Rosemary Seelaus. Anaplastology as defined by the IAA (International Anaplastology Association) is a branch of medicine dealing with the creation of prosthetics to rehabilitate an absent, disfigured, or malformed portion of the face or body, typically caused by cancer, trauma or a birth defect. Robert and Rosemary began working together to explore opportunities to inject new technology-driven techniques into the field of anaplastology; this relationship allowed several undergraduate and graduate design students to participate in a variety of research activities.

Ben King's particular focus is in the area of three-dimensional modeling and prototyping for surgical planning, visualization and education within iRSM's technology-driven MMRL (Medical Modeling Research Laboratory). The MMRL was established in 2005, coinciding with the author's student practicum, and houses a variety of advanced digital technologies that enable new approaches to clinical application, research and education within the surgical realm. The author's position as a member of staff within an interdisciplinary team has further enhanced the integration of industrial design students and is one of the driving considerations in the development of the work to be presented.

Table of Contents

List of Figures and Illustrations

Introduction

There are varying degrees of feeling out of place. Most people have experienced a bad hair day, the shock of being under or over dressed for a social or professional situation, or perhaps the anxiety associated with having the quality of their work evaluated by their peers. The way we are perceived by other members of society can have a significant impact on our social interactions, affecting confidence and the ability to integrate and succeed within a variety of contexts. Everyone has some measure of control in how they are perceived by others depending on the language they use, the clothes they choose and the attitudes and behaviors they employ. However, for many individuals with physical disabilities, they often perceive being devalued or negatively judged prior to any significant social interactions. Common challenges related to personal representation and expression are potentially compounded by a dialect of social stigma relegated to individuals with a disability. Artifacts such as prosthetic limbs, wheelchairs, eyepatches and crutches are invariably related to disability, but is there a way to change the visual language to include elements of design and fashion that challenge current notions of disability? Can objects that are engrained as utilitarian evolve into objects of desire?

Artifacts relating to a variety of impairments have largely been developed for functional purposes, without significant consideration in regards to the emotional connection and social implications for the wearer. These are not objects to be ashamed of, and perhaps by challenging the established aesthetics of mimicry and disguise, more open conversations and a fundamental understanding of how and why an individual needs a device associated with disability will challenge societal stigmas. Through the use of digital technologies, a customizable workflow based on the principles of medical modeling will be suggested to encourage new conversations in expanding the visual language of disability.

Disability and Design

The written language used in this document is derived from the approach of Graham Pullin's *Design Meets Disability*. As Pullin states, any language revolving around the topic of disability is politically charged. For this reason, the definitions that will be used are based on wide spread conventions (1-2). The World Health Organization defines disability as "a complex interaction between features of a person's body and features of the environment and society in which he or she lives". Further elaboration from the World Health Organization identifies disabilities "as an umbrella term, covering impairments, activity limitations, and participation restrictions"; impairments will refer to specific problems relating to the function or structure of the body.

Other terms that Pullin references that can divide people based on education and experience are design and designer. These terms can have very broad or very specific meanings depending on the individual and experience; within the context of this paper, designer will signify individuals emanating from an art school culture, including industrial, furniture, fashion and graphic designers. The major distinction in terminology is from that of an engineering culture, which includes, but is not limited to, mechanical, electronic and software engineering (3).

In addition, not all ideas presented will be relevant from a cultural standpoint, and thus designs and ideas in this document have a particular focus on a North American audience. It is not the goal of this research to introduce or redefine terminology, but simply to avoid confusion where there is the potential for misinterpretation.

Rationale

Health based solutions are generally focused on functionality, and justifiably so; however, there is both a need and opportunity for designers to participate as vocal advocates for creativity, empathy and technology in unison with functional considerations within the health sphere. In shaping new options for physical impairments, the incorporation of self-expression is a key element in evoking pride and confidence from the wearer. Most devices associated with disability are worn externally, and are generally visible. While advanced applications such as research regarding robotic prosthetics shows great promise, they lead to questions of public availability, candidacy and risk (Kamen). There are instances such as hearing aids where the wearer can conceal the device with hair or in the case of a prosthetic leg, with pants, but there are generally visual indicators that reveal the disguise. Hearing aids do not truly match skin tone, prosthetic eyes are static and do not move like functioning eyes, and prosthetic limbs do not move like natural limbs. Functionality and mimicry serve a purpose: not everyone is comfortable displaying their differences. Unfortunately this culture of hiding differences simply perpetuates a lack of understanding. If an object can project appeal and intrigue, even if it projects something unfamiliar, it may encourage people to inform themselves and become acquainted with what was once foreign.

The challenge in projecting appeal is partially based in the lack of options available to wearers; choice is found in many other realms of consumer culture. Not everyone wants to buy every product, and as a consumer, by filtering through a variety of options, they can identify what they want to visually communicate to other members of society. The way someone styles their hair, the type of clothes they wear, their choice of shoes all provide information to other members of society. Although design for disability requires the incorporation of specialized function, these devices

become accessories for the wearer. If an individual is proud of their accessory they will be more confident than if they are bound into a situation where they must wear a device for functional purposes that does not best represent their identity. If these devices are considered as functional fashion, a new dynamic in design considerations can be developed. By being sensitive to how we differentiate ourselves from one another through what we wear, it becomes apparent that fashion "affects the attitude of most people towards both themselves and others, though many would deny it." (Svendsen 10). Clothing is a projected manifestation of who we are as individuals and can make a clear allusion as to who we want to be perceived as, providing a venue for symbolic communication (Davis 3-4). Through this visual mode of communication, it becomes imperative for the wearer to feel empowered. Undoubtedly, there will be individuals that prefer one design to another, but without choice, how does an individual feel confident in making a decision regarding such a disruptive change in identity? Should wearers of objects associated with disability be limited in choice?

The economics of supply and demand certainly have a considerable impact on the development and refinement of the objects we use and consume. Simply put, almost every individual in the developed world owns a cellphone; not everyone needs a prosthetic eye, limb or a hearing aid. Substantial research and development is placed on devices where there is the potential for significant return on investment due to the size of the market. This results in the involvement of designers within a team to research and conceptualize designs that will be more attractive and usable, which will result in better sales. Due to the much smaller potential market, the availability of a variety of options for devices associated with disability is generally limited to satisfying the needs of as many individuals as possible. When traditional manufacturing techniques are employed, cost

usually dictates the amount of choice available to the individual. In the realm of disability, this has generally resulted in functional objects that attempt to mimic what was lost or damaged.

These exclusively functional solutions certainly have merit, but they do not necessarily evoke positive emotional connections from their wearers or onlookers. Because most design for disability seeks to either mimic or hide devices, it conveys a visual language of replacement in the case of prosthetics, or concealment in the case of hearing aids. Appealing to rational, functional needs does not sufficiently appease individuals looking beyond the functional, particularly when the object is not simply a consumer product such as a waste basket, but a defining physical characteristic. According to research theories in social psychology from Asch, a key element in social interactions and identification is known as 'central traits', such as a defining facial feature, attractiveness or status in society (qtd. in Chin 75). Chin asserts that an individual's disability is often perceived by other members of society as a central trait. If an individual uses a wheelchair, other people will associate the device with the individual and future references regarding that individual will revolve around wheelchairs. Research also indicates that the individual in the wheelchair (or any disability) does not typically regard their disability as their defining characteristic (Chin 75-76). If this artifact is to be perceived as the defining attribute of an individual from other members of society, it seems logical to propose that most people would want some measure of choice and control in defining that attribute. As Pink relates, mundane products such as trash cans and toilet brushes have been transformed from utilitarian into objects of desire; if these categories of objects can be designed to elicit want and desire, perhaps that same consideration can be applied to design for disability. Engineers will always need to figure out the

functionality of objects, but if those objects “are not also pleasing to the eye or compelling to the soul, few will buy them” (36).

Unfortunately for the consumers of disability, the economics related to their product category has seemingly stunted the incorporation of empathy and appeal into the design of these objects. Research has demonstrated that there is no difference in personality between individuals with or without disabilities (qtd. in Chin 75). Individuals with disabilities have the same emotional responses to products and environments as those without disabilities. As Pink states, if all of our decisions were driven by purely rational factors, candles would not be a $2.4 billion-a-year business. Electricity and lighting are commonplace and inexpensive, and yet we seek out alternatives that reach beyond logic and the need for light, searching for transcendence and beauty (36). These same factors that influence our desire for ambience resonate through our homes and wardrobes, and ultimately impact our comfort levels and ability to interact with others.

Having a disability does not necessarily mean an individual will encounter psychological problems, but as Chin explains, there is a commonality among people with varying disabilities in accepting the challenge of being devalued in society. For the individuals that do encounter psychological difficulties, “devaluation and non-acceptance seem to be the primary causes of their difficulties. The natural solution to most of the specific psychological problems associated with disability will logically be personal validation and acceptance” (74). Finding personal validation by being proud of the object that others attribute as your central trait will potentially facilitate the ability of individuals with disabilities to find this acceptance.

So how does one integrate functional and emotional considerations in a way that is both meaningful and economically viable? The concept of the 'Long Tail' was popularized by Chris Anderson, and details the shift in consumerism from selling mass quantities of a few popular items, to the strategy of selling unique items in smaller quantities. As Anderson describes, our "culture and economy are increasingly shifting away from a focus on a relatively small number of hits (mainstream products and markets) at the head of the demand curve, and moving toward a huge number of niches in the tail" (52). In regards to design for disability, employing a three-dimensional data driven process customizable to the individual eliminates the physical constraints associated with off-the-shelf solutions. As Anderson explains, a Long Tail is simply culture reconfigured by economic scarcity, but it is only triggered through the reduction of costs in being able to distribute to these niches. This has largely been facilitated through digital distribution of data and the ubiquity and power of search technologies. Once distribution is established, the sheer quantity of niche products can collectively rival the massively popular hit products (53). People have more freedom than ever to match their individual needs and interests, as retail has essentially been democratized through digitization.

In regards to design for disability, a number of objects could potentially be customized from a digital scan of an individual, be rapid prototyped and delivered to the customer in a relatively short amount of time. The intent of the present research is to take the principles of medical modeling, which is generally used for analyzing and reacting to a clinical problem, and applying those principles into a workflow that enables creative discovery in regards to designs for physical impairments. The process will use available tools from established digital medical processes and inject influences from design and fashion in order to develop concepts that do not mimic or replace damaged or missing physical traits or functionality. It will also use

the existing anatomy to highlight and express a new aesthetic while being sensitive to the functional requirements. The intent is that this customizable process will encourage interest in the medical realm, in particular, design for disability, from industrial design students and design professionals, as well as other disciplines and individuals who want to participate in questioning current visual definitions, and define and design options for a new visual language associated with disability. Additionally, in visualizing these artifacts, the hope is that it eventually willprompt new discussions in regards to the perception of products associated with disabilities from the perspective of clinical professionals. The combination of clinical knowledge, imagination, interdisciplinary thinking and digital technology has the potential to challenge and improve a variety of areas within health care, but it requires involvement from clinicians that are willing to invite individuals outside of their expertise to challenge their own workflows. Creative professionals that have experience with digital technologies add a new dynamic to clinical environments that enables exploration into areas of visualization and manufacturing, as well as diverse perspectives in regards to patient empathy.

As architect and designer Fiona Raby explains in Gary Hustwit's film *Objectified*, design is often about exploring a multitude of problems and solving them. These solutions in many cases are not the definitive answer; the solutions are fundamentally meant to ask further questions. Stimulating new conversations and debate is paramount; encouraging a diverse group of designers and collaborators to enact on these conversations may yield ideas that blur the boundaries of fashion and disability. Fundamentally, the intent of this research is to demonstrate concepts that will spark conversations while detailing a road map that encourages people to pencil-in their own thoughts and detours as they travel towards new visual destinations.

Medical Modeling

As Bibb describes, medical modeling, alternatively referred to as biomodelling, "is the creation of highly accurate physical models of human anatomy directly from medical scan data. The process involves capturing human anatomy data, processing the data to isolate individual tissue or organs, optimising the data for the technology to be used and finally building the model using rapid prototyping (RP) techniques" (1). These models are used in evaluating patients, as well as planning and practicing surgeries in three-dimensions, as opposed to referencing two-dimensional data such as an x-ray. The fundamental elements of medical modeling can be separated into three distinct categories of data acquisition, manipulation and output. To eventually have a physical, highly accurate representation of a patient, there must first be a form of data capture that can be transferred in a way that is readable by computer software which can then communicate with a rapid prototyping device. The types of data acquisition range from sophisticated hospital based systems that must be operated by highly trained technicians to relatively simple hand-held scanners that can be connected to a laptop and operated in most environments. As Bibb explains, the two general categories of scanning modalities for capturing digital data related to the human body are those that capture both internal and external data and those that only capture surface data. Hospital-based imaging such as Computed Tomography (CT) and Magnetic Resonance (MR) employ different techniques to capture cross-sectional images of both internal and external structures that can be reconfigured and segmented using computing algorithms to display regions of bone and soft tissue (8).

These modalities result in highly accurate and desirable three-dimensional models, but are typically only used for direct patient care and clinical research. There are economic factors related to performing a scan, and in

the case of CT scanning, the patient is exposed to radiation, which is not recommended unless that individual truly requires assessment or intervention. While these data are extremely useful, they are generally only accessible to researchers if a facility has an archive of available data where consent for use has been obtained or acquired with ethics approval. In addition, that data must have been acquired using an appropriate scanning protocol. If either of these modalities is executed without a standard scanning protocol,the resulting data sets are unusable for three-dimensional modeling. If designers are included in a project from the onset, it is plausible that all required information can be acquired parallel to clinical assessments using an established protocol. If the scanning technician is made aware of the end uses of the data, different algorithms relating to processing and export can be applied to a scan that enables multiple end users to view or manipulate the data based on one capture. In the case of a CT scanning protocol, as used for hundreds of clinical medical models at the Medical Modeling Research Laboratory (MMRL), the technician would need to perform a helical axial scan at one millimeter slices with a zero degree gantry tilt at a standard algorithm resulting in a sequence of DICOM (digital imaging and communications in medicine). DICOM is a method of transferring data from medical imaging modalities that arose from the joint committee of the American College of Radiology (ACR) and the National Electrical Manufacturers Association (NEMA) to standardize the processing of medical images in the 1970s (Bibb 32-33). This has alleviated the challenges of transferring proprietary formats across networks and has enhanced the ability of medical professionals to communicate across physical borders.

While hospital-based scanners provide advantages in accuracy and the ability to segment both internal and external anatomy, the disadvantages likely will deter most designers who do not have affiliations with medical

institutions or experience in processing DICOM data. The other category of scanning, three-dimensional surface scanning, offers its own array of advantages and disadvantages, but is likely more user-friendly as a tool in generating concepts for design projects. Surface scanning, also designated as digitizing or non-contact scanning, has been used for many years by engineers and product designers as a means of accurately evaluating and integrating the dimensions of real objects with CAD (Computer-Aided Design) models without the need for calipers or other means of manual measurement; this has lead to the process being referred as 'reverse engineering' (Bibb 8-9). Speed, accuracy and the ability to archive and share files are among the numerous reasons this type of scanning is invaluable in design and engineering. Surface scanners utilize various harmless imaging technologies to digitize thousands of data points, making them ideal for capturing surface human anatomy. They are offered in a variety of configurations, ranging from full-body scanners that require a dedicated physical environment, to portable hand-held scanners. This type of data capture offers the advantage of being immediately exported to a usable file format for a variety of CAD software, whereas CT and MR data require translation software such as Materialise Mimics to convert the captured DICOM into a usable format. Translation software such as Mimics is extremely costly; if a designer does not have access to the program or the time to properly learn the software, the benefits of a CT or MR quickly diminish.

With these factors in mind, a Cyberware 3030 RGB 3D Digitizer was used in capturing the surface data for the designs that will be discussed in this project. This particular scanner has difficulty capturing undercuts and cavities and may produce inaccuracies derived from movement, as the data are captured while the scanner rotates. Any movement that occurs while the scan is being completed will cause inaccuracies or embellishments that

do not correspond to the actual anatomy. This becomes extremely problematic if an individual being scanned is unable to stay still for approximately fifteen seconds. There are more refined systems for capturing surface data of human anatomy such as the 3DMD digital stereo photogrammetry system. The system utilizes a series of cameras that capture data in unison in approximately 1.5 milliseconds. After witnessing and participating in several demonstrations with 3DMD, the system displays an accurate and repeatable process based on pods containing multiple cameras that can be moved and configured depending on the required scan region. Pods can be added, resulting in a full body capture if necessary or extremely detailed capture of small regions. The data capture is instantaneous, as processing occurs following the initial capture, not while the capture is occurring, as in the case of the Cyberware system. This virtually eliminates all inaccuracies incurred by alternative systems that require time or user involvement. Although there are facilities that own 3DMD systems within Edmonton, for the purpose of this project, the Cyberware scanner offered a favorable situation as it is located in the MMRL and is only in use for scheduled appointments. Additionally, there is a high degree of familiarity with this system, as it has been used in the MMRL for a variety of clinical research projects over the course of five years. This enabled flexibility in terms of repeating scans as ideas were generated, and ensured data were appropriate for the digital manipulation phase.

The manipulation portion of medical modeling is generally completed through CAD software such as the aforementioned Materialise Mimics, 3D-Doctor or Amira. When it became apparent in the 1990s that rapid prototyping devices could interact with medical three-dimensional data, software developers began offering options that reflected the needs of those users (Bibb 1). These software programs have a specific focus on

segmentation and analysis, and although they offer a variety of tools, they are generally not used for complex object creation as performed in more robust CAD packages intended for designers and engineers. Object creation based on human anatomy can be quite challenging for designers, as most anatomical information has been extracted from sources such as *The Measure of Man & Woman*. This is a phenomenal source of information of two-dimensional anthropometric data; unfortunately, this can be problematic if the design process requires an inherently 3D solution (Tilley 4). Medical modeling processes provide the means to react to and design in ways that, if done manually, are extremely cumbersome and costly. Just as surgeons employ three-dimensional planning with medical models, so too can designers with their prototypes. There are options for 3D anthropometry available (Tilley 5-6), but the ability to both virtually and physically reference yourself, a team member or a patient offers immense advantages in understanding and reacting to anatomy. Rhinoceros 3D was chosen as the central CAD software for design generation based upon this consideration, as well as the knowledge that there are an immense array of low cost plug-ins available that enable the manipulation and conversion of various formats. Other CAD such as the haptic device-driven SensAble Freeform and the computer-aided industrial design software Autodesk Alias Studio offer attractive packages, but at a significant premium. If a designer has access to these resources, they can certainly design with these software, but to encourage a wide range of individuals, Rhino was used to demonstrate that low-cost alternatives can be as effective in developing concepts.

The third component of medical modeling is the output, which is generally produced through rapid prototyping. As Bibb explains, rapid prototyping is the general name used to describe computer-controlled machines that are able to manufacture physical items directly from three-dimensional

data (59). As Bak details, rapid prototyping offers several cost advantages to conventional tooling:

> - *Waste*. Unlike subtractive machining processes that generate waste in the form of chips and unused stock, additive ... processes use little more material than the object requires. In addition, disposal or recycling costs are avoided.
> - *Inventory*. Generation of objects of various sizes from a common pool of powdered material as opposed to a diverse inventory of pre-sized stock cuts cost.
> - *Labor*. Near net shape eliminates the skills and time needed for multi-part design, machining, and assembly.
> - *Quality control*. As production is driven by digital information, there is less opportunity for human error.
> - *Set-up*. If a single material is used, set-up costs are principally focused on CAD file preparation and verification. These, however, are done off-line, and do not impact machine production utilization. (341)

This enables increased design flexibility, as variations of complex patterns have minimal impact on the actual cost of the prototype if the proportions are similar. Additionally, there is an increasing diversity of material choices that include durable options such as ABS (Acrylonitrile butadiene styrene) plastics, metals and rubber. The growing focus in the rapid prototyping industry, and the key factor for further proliferation, is transitioning material properties from prototypes to being acceptable for small runs of production quality customizable products (Bak 344). As Wohlers explains, the focus and challenge for companies in this industry is to reduce machine costs and increase ease of use and maintenance (qtd. in Bak 340). For designers developing concepts based on three-dimensional

data, there are a variety of options for printing locally on campuses and through rapid prototyping services such as FineLine Prototyping and RedEye Express. These service-based companies offer direct quotes from uploaded 3D files as well as price comparisons for a range of materials in combination with expert advice on material choices based on end use. Although most designers initially have difficulty differentiating the advantages between rapid prototyping methods such as SLA (stereolithography), multijet modeling and SLS (selective laser sintering), there is an abundance of online communities such as the Open Directory Project that list the types of systems and commercial service providers that will be best suited for their projects. As the production economics related to rapid prototyping change, the industry likely will continue to refine the processes of offering production quality materials, enabling customizable designs at a relatively attainable price point.

Challenges

Aside from the technical challenges, one of the key elements in exploring new directions involving designers within the health sphere is engaging and attracting design students. Imagine student sketchbooks filled with as many concepts for prosthetic limbs, wheelchairs and crutches as sketches for high-end furniture, home accessories and athletic shoes. All of these objects fill our physical environments, and while some currently are perceived as more glamourous than others, perhaps a shift in perception can be encouraged through student work that will eventually translate into their professional careers. The appeal of exploring new territory, defining aesthetics and helping a variety of individuals certainly has the potential to attract a myriad of students. The challenge of transforming perceptions in regards to the medical realm is nonetheless substantial.

Medical design does not currently have the prestige associated with mainstream product and furniture design that is embodied by the likes of Philippe Starck and Karim Rashid. As Pullin states, designers entering the medical realm tend to be more pragmatic and focused on user-centered problem solving. A mix of practical designers, commercial designers and 'enfants terribles' seeking to stir preconceptions of existing products is necessary to address both current needs and future directions (59). The pragmatic concerns related to patient care are rightfully the most important elements of any health care environment, but this does not always provide an inclusive environment for collaboration with non-medical professionals, particularly those that challenge entire systems instead of simply proposing incremental improvements to the problem that is presented. There is certainly an abundance of creative opportunities; they simply have not been fully advertised or explored due to the issues of accessing both health-based resources and personnel.

As Macdonald explains, current health systems are structured specifically to accommodate the organization and clinical professionals, resulting in solutions intended for and directed by these stake holders (27). The organization is looking at an array of financial and materials restrictions, while clinical staff often look for solutions that streamline the service and ease of implementing care based on available resources. The challenge as a designer is to explore new ways in which to implement creative design research skills and processes that complement the organization and clinical stakeholders, while stepping beyond the available and searching for comprehensive new approaches. Macdonald further discusses that health professionals often have hesitations in understanding the role of design in health care, but eventually come to appreciate the boundary-less approach of design in uncovering clarity within health environments (27).

Part of the challenge in being able to expose this clarity is simply the opportunity to engage with health professionals. Unfortunately, most health care facilities have a defined hiring process and established positions that do not incorporate designers. Due to the visual nature of the design profession, job applicants are generally required to submit a portfolio displaying a range of visuals such as sketches, renders and photographs of prototypes as well as written descriptions related to research techniques and methodology; this is useful in identifying talent and expertise across a broad range of skills. This presents an enormous potential shift in bureaucratic culture, as it is unlikely there would be anyone within the health care hiring structure with the experience to properly evaluate potential candidates. It is difficult to assess mediocre from good and good from great candidates in virtually any field if the evaluator is not immersed in the nuances of the profession.

There are examples of integrating designers within health care such as the SPARC Innovation Program at the Mayo Clinic, but very few health care facilities have the interest or capacity to incorporate designed-based research. SPARC stands for See-Plan-Act-Refine-Communicate, and was established with the input of renowned design firm IDEO as a center for health innovation. It presents a hopeful glimpse into how potential interactions between patients, designers and clinical professionals could develop, but is certainly not the current standard.

This lack of design employment in health care is largely due to the relatively young nature of the Industrial Design (ID) profession. Although most people do not understand the intricacies of professions such as engineering or surgery, there is a general understanding based on years of familiarity. ID does not have this luxury, and is further complicated by a

seeming inability to present a clear identity. The IDSA (Industrial Designer's Society of America) "is the world's oldest, largest, member-driven society for product design, industrial design, interaction design, human factors, ergonomics, design research, design management, universal design and related design fields", and yet even this organization cannot provide a concise definition. The IDSA defines ID as "the professional service of creating and developing concepts and specifications that optimize the function, value and appearance of products and systems for the mutual benefit of both user and manufacturer." This definition, although accurate, is cumbersome, especially when trying to describe the profession in conversation. ID is a visually literate profession, focusing on the language of objects, the systems and services associated with these objects and the people that use them. When someone asks 'What do industrial designers do?' there is generally not a straightforward answer.

A myriad of design schools, professional organizations and design consultancies offer their own definitions of design that range from elusive to ambiguous. This likely is due to the need for design to be adaptable to new processes, materials and trends, resulting in multi-faceted approaches that are constantly evolving and often overlap and incorporate elements from a variety of professions. This is not a discussion on the merits of one definition or another, it is simply a statement that the more difficulty professionals have in explaining their skills and area of expertise, the more challenging it likely will be to interact with and attract collaborations with other professions. This is particularly poignant when trying to interact with a field that constantly deals with tangible and pragmatic situations such as medicine.

In order to entice collaborations, value must be demonstrated. Student designers present an immense opportunity, as education, experience and portfolio projects are adequate forms of currency. It enables the students to explore new avenues of design, while expanding the awareness of the profession from the perspective of medical professionals. As awareness increases, the potential for design-based health care employment parallels this growth. Incorporating designers into interdisciplinary teams of medical professionals creates an entirely new dynamic as opposed to the traditional consultant-client relationship. Design for disability provides a platform for designers to demonstrate their value and ability to imagine new products, systems and interactions. With increasing access to medical professionals, the conversations are just beginning and the opportunities are simply waiting to be grasped.

Designs

In determining the artifacts for discussion and design, selection was based on a variety of individual factors. An initial list was compiled of objects associated with physical disability that consisted of: wheelchairs, crutches, eyepatches, hearing aids, prosthetic limbs, braces and a variety of devices for the visually impaired (navigation, watches). From this list, artifacts were filtered based on the ease of employing the process of medical modeling and the predicted usefulness of employing the principles of digital scanning, manipulation and rapid prototyping. Eyepatches were chosen for ease of scanning, as well as access to professionals working in the field of facial prosthetics at iRSM and a seeming lack of available alternatives. Hearing aids were chosen based on ease of scanning and previous experience designing bone anchored hearing aid concepts with professional Audiologists from iRSM. Additionally, hearing aids seem to have imminent potential to emerge as fashionable accessories much like eye glasses.

Prosthetic legs were chosen largely for the desire to design at least one object in which there was not a great degree of familiarity or direct access to patients and professionals. Encouraging participation in the discussion of design and disability may prove difficult without direct contact with patients and professionals, but using alternative means such as online forums, video blogs and other web resources facilitates one of the major stumbling blocks of idea generation in this field. Exploring outcomes not solely based on patient and clinician input may yield interesting solutions, and may also attract the types of designs and designers previously described by Pullin as capable of stirring preconceived notions of existing products (59).

In order to organize these three projects, several open-source software packages were evaluated. The central software used is VUE, which stands for Visual Understanding Environment, and is based at Tufts University (Fig. 1). VUE presents an opportunity for a variety of academics and professionals to organize their work, maintain text and visual references throughout a project and communicate within a team if necessary. VUE is a digital project management software that allows flexible structuring of digital resources such as text and images, as well as active linking to online pdf documents and books. Utilizing connecting nodes and a layer based organization system, ideas can be color coordinated and set to different layers as the project expands and more information or concepts are added. This enables complex visual mapping between ideas, essentially providing a digital mood board that can be saved, transferred and used as a presentation environment in place of software such as Powerpoint and Keynote. The flexibility of dragging links and images directly from the web facilitates the process of collecting web-based information within one

source, rather than compiling bookmarks, hand-written information or relying on memory.

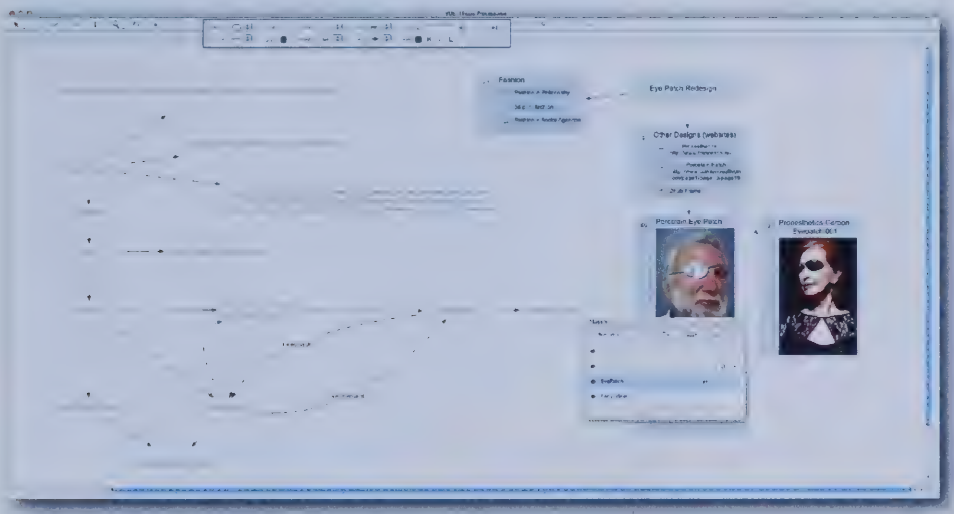

Figure 1 VUE screen combining quotes and images related to eye patch design

Visually clustering information and existing work related to eye patches led to the realization that available options outside of patches, pads and prosthetics is extremely limited.

Designer Damian O'Sullivan has produced eye patch concepts that focus on communicating artifacts aiming to provide a sense of home as opposed to the unsightliness of a hospital. O'Sullivan seeks alternatives that offer comfort in moments of need which hopefully lead to dignified solutions. The two alternatives are titled '100% Porcelain' and '100% Carbon', maintaining the familiar look of an eye patch while communicating the poetic beauties of the chosen materials (Fig. 2). The concepts focus on the inherent material qualities of porcelain and carbon fiber, evoking sensibilities of elegance and high performance respectively. These artifacts project detail and quality not normally considered within design for

Fig. 2 O'Sullivan's eyepatch designs: 100% Porcelain and 100% Carbon

disability, while maintaining the familiar shape of an eye patch. This leads to questioning the perceived value of the objects we are familiar with; in developing a new alternative to the eye patch, the desire to communicate a differing aesthetic became paramount.

This led to the discovery of the designs of Francesca Lanzavecchia (Fig. 3). Francesca's 'ProAesthetics', an amalgamation of prosthetics and aesthetics, explores patterns, materials and challenges the perceptions of established medical artifacts. Lanzavecchia's designs for back and neck braces are expressive representations of their wearers, demonstrating alternatives that vary from elegant to boisterous.

Back braces that represent luxurious second skins are balanced by playful concepts such as 'Polly' that enable the wearer to store prized possessions.

Fig. 3 Francesca Lanzavecchia's Polly and Second Skin back brace designs

The second skin design is reminiscent of a finely crafted garment with a functional purpose. This led to the realization that glasses essentially serve as a functional accessory for eyes, providing protection or enhancement. The recognition that custom fit glasses could be designed from a three-dimensional laser scan led to a search for projects incorporating digital capture and rapid prototyping. Industrial designer Kathinka Bryn Bene developed a concept for sunglasses that provides a customizable interior frame dependent on the individual's facial features with minor adjustments to the predefined outer frame. The final sunglasses are rapid prototyped using selective laser sintering, providing a flexible yet durable material. Initial concept sketches sought to combine the detail of Damian O'Sullivan's eye patch, the poetics and playfulness of Francesca Lanzavecchia's designs and technical considerations of Kathinka Bryn Bene's project.

Fig. 4 Initial sketches

Dispatch Eyewear

Concept sketches took inspiration from a myriad of products that cover eyes such as performance eyewear, swim goggles and snowboarding goggles (Fig. 4). With only one eye requiring a space for a frame, the damaged eye provided a canvas to communicate individualized patterns or logos. The International Organization for Standardization utilizes a white cross on a green background as a means of communicating first aid; this cross in many iterations has visual connotations related to health and healing. The use of the cross thus potentially communicates a state of damage or healing to onlookers.

In order to test the validity of the concept, a section of a surface scan was printed using a 3D Systems Invision multijet printing system (Fig. 5). The

Fig. 5 Armature with a layer of Super Sculpey

Fig. 6 Clay modeling on the Invision armature

intent was to use the model as an armature to support Super Sculpey, which is an oven-bake clay sculpting compound (Fig. 6). The printed Invision material provides the ideal base for quick ideation with Super Sculpey, as the rapid prototyped material is finished by heating it at high temperatures to remove the support structure. This enables the rapid prototyped armature to be heated in the oven until the clay has hardened. This process eliminates the need for a wire skeleton, while also providing a realistic model to work with while shaping initial ideas in three dimensions.

Fig. 7 Rough 3D modeling renders

Following manual clay modeling, rough three-dimensional models and renders were completed to visually communicate the concept to a variety of individuals including designers, medical professionals and patients (Fig. 7). Informal responses indicated that the idea was both visually and functionally appealing. It became apparent that further refinement would require testing against a human subject.

Fig. 8 Cyberware scan of the author

A scan of the author was performed using iRSM's Cyberware scanner following a clinical scanning protocol to ensure accuracy (Fig. 8). The scans were imported into Rhinoceros 3D as STL files, which is a standard file type for transferring models intended for rapid prototyping (Fig. 9). Modeling was completed using a combination of native Rhino 4.0 tools and the plug-in T-Splines. T-Splines enables complex organic modeling while retaining the watertight qualities needed for rapid prototyping. T-Splines facilitates the process of developing smooth organic shapes, enhanced by the ability to leverage Rhino's tools to complete more detailed

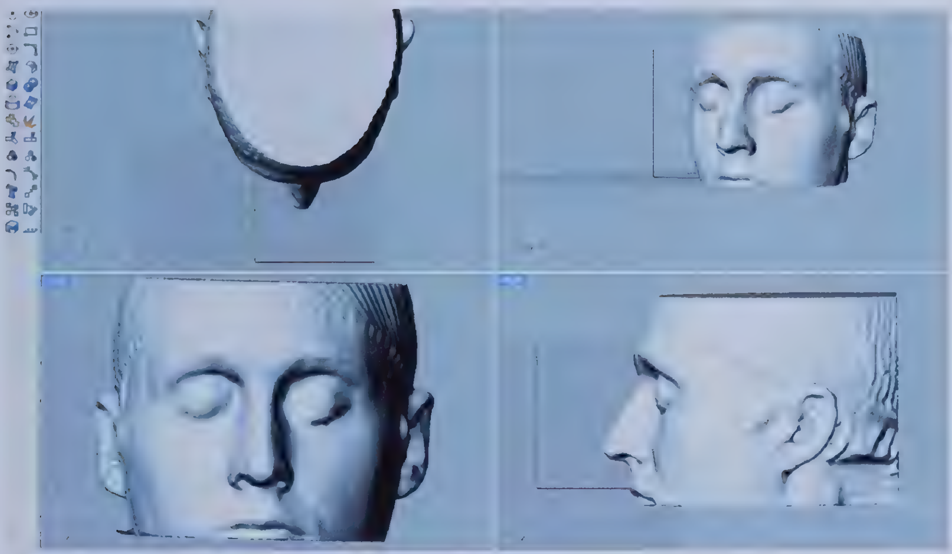

Fig. 9 Importing the 3D scan into Rhino

modeling such as embossing and filleting. This results in the flexibility to create multiple design iterations within a short time (Fig. 10).

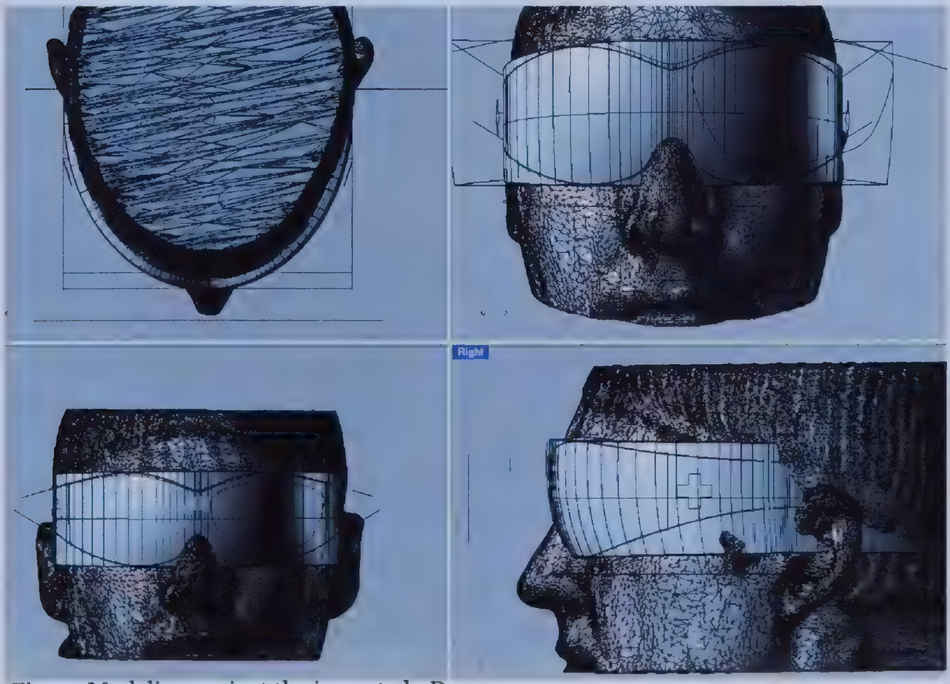

Fig. 10 Modeling against the imported 3D scan

Fig. 11 Sequence of rendering the first frame and physically testing for fit, accuracy and comfort

Fig. 12 Refining the styling and fit

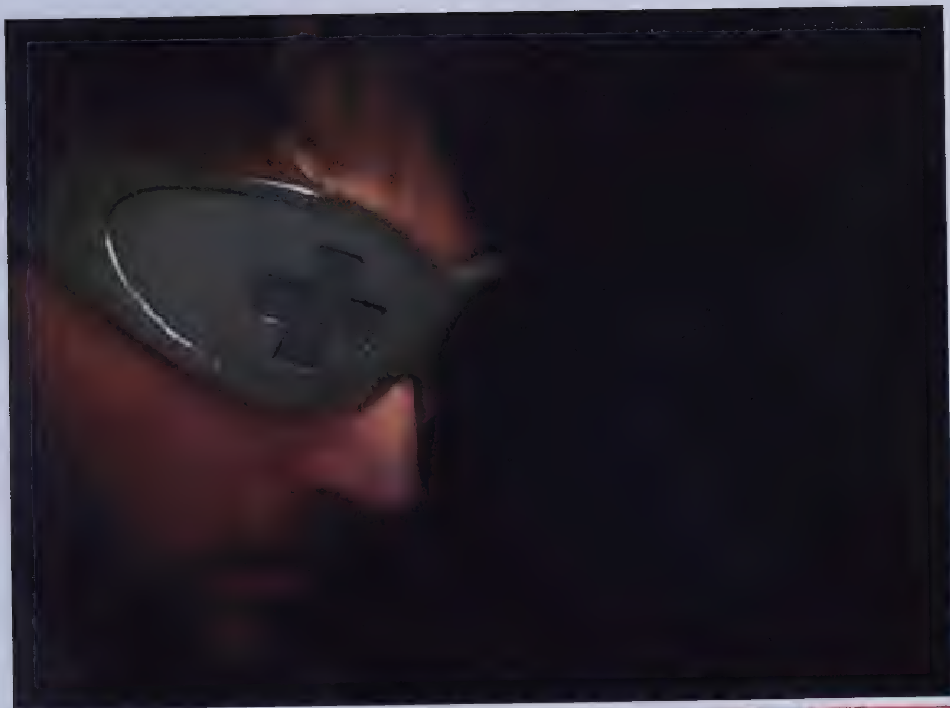

Fig. 13 The first finished concept demonstrates sleek styling akin to Oakley sunglasses and features an embossed symbol

Fig. 14 The second finished concept demonstrates a wider frame for optimal coverage with a raised symbol

Once designs were completed, a boolean difference was performed against the face to create the custom fit for the interior frame, resulting in a relatively tight seal that covers the damaged eye (Fig. 11, 12).

The name 'Dispatch' is a combination of disability and eye patch. The word play suggests the elimination of aesthetic conventions in favor of considering this as eyewear fashion. The design offers a more durable alternative to disposable eye pads and a better fit to eye patches. The challenges associated with prosthetics such as creating lifelike skin tone and a lack of eye movement are circumvented with this distinct customizable alternative.

Helix Hearing Aid

The development of a hearing aid concept aimed to follow a similar process as the development of the eye patch. In exploring alternatives to traditional hearing aids, perhaps the most striking and confident design is from Designaffairs Studio. The Deafinite Style hearing aid does not

Fig. 15 Designaffairs Studio Deafinite Style hearing aid

attempt to hide the device; the hearing aid is essentially a piece of jewelry that presents the wearer with the opportunity to express their personal style (Fig. 15). Onlookers are more likely to associate the hearing aid with a fashion statement as opposed to a disability. Such a distinct style will likely limit mass appeal, but it demonstrates the ability to transform the visual definitions of a device from mundane to expressive.

An example of a device that shares many properties with a hearing aid but has garnered mass appeal is the Jawbone headset designed by Yves Behar (Fig. 16). As stated in the product overview, the proprietary technology for Jawbone headsets was initially developed for military helicopter pilots and tank commanders to eliminate background noise while enhancing speech quality. This is similar to how digital hearing aids discriminate and amplify speech in noisy environments while regulating background noise. This demonstrates the potential convergence of technology for a commercial audio product with an assistive device.

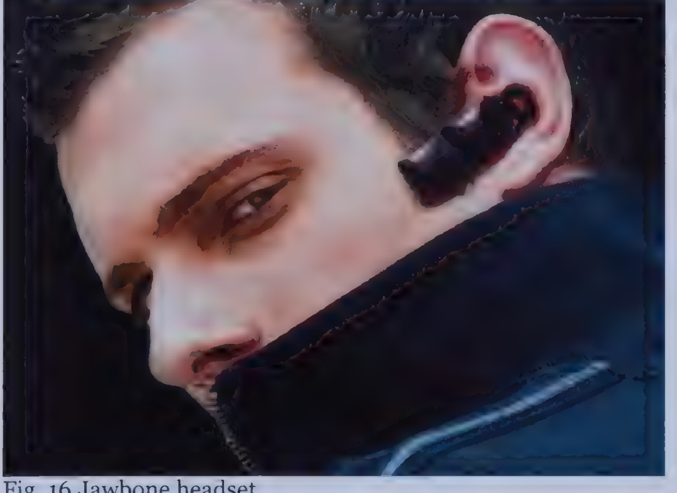

Fig. 16 Jawbone headset

The differentiating factor is that the Jawbone headset is designed, marketed and perceived as a luxurious piece of technology, while most hearing aids are not recognized as having this level of appeal. If a device that functionally parallels hearing aids can offer desirability, there is

Fig. 17 Initial hearing aid sketches

certainly the potential to develop hearing aid concepts that achieve a similar level of allure.

With these two projects providing a reference for combining style and technology into hearing aid design, exploration of a new concept incorporating a digital workflow began. Initial sketches highlight fluidity of shape and the potential for a more organic appearance (Fig. 17). Utilizing the same

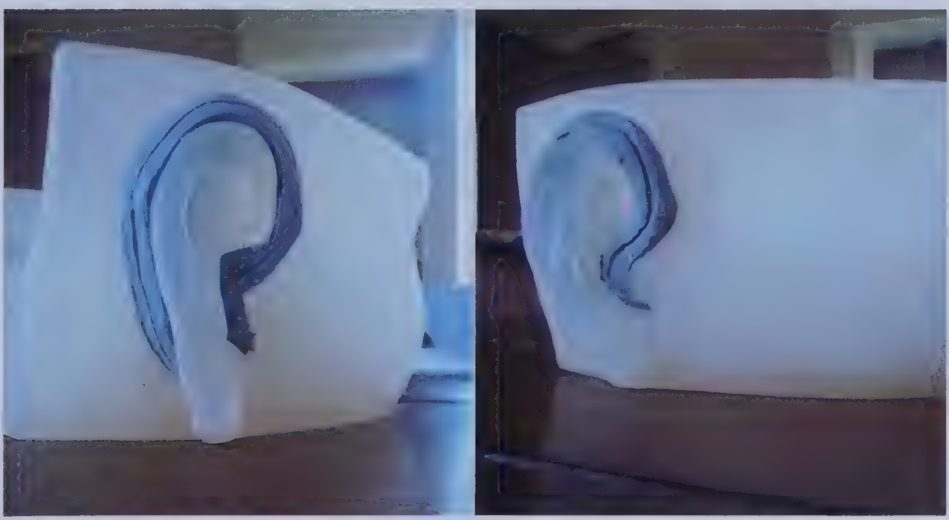

Fig. 18 Transitioning to manual clay modeling

Fig. 19 Further concept generation using manual clay modeling

medical modeling approach as the Dispatch concept facilitates the ability to create shapes that react and move with the natural shape of an individual's ear.

Fig. 20 Rough modeling renders of hearing aid concepts

Fig. 21 More refined concept incorporating the helix

Upon completing rapid sketches, the same approach of transitioning to clay modeling was used (Fig. 18, 19). Forms that integrated with the ear were generated and the ability to use the three-dimensional scan to create an interior custom fit was readily apparent. Rough modeling was once again completed to visually communicate ideas to a variety of individuals, once again to informally gauge interest and reactions (Fig. 20).

Fig. 22 Rapid prototype fit test

A smooth exterior shape was explored that used the helix of the outer ear and the ear canal as attachment points (Fig. 21). This creates a shape that encompasses the ear, differentiating itself from

headsets that communicate movement towards the mouth. This design attempts to communicate that use and sound are intended for the ear. Using the previously acquired scan of the author, a rapid prototyped model was fabricated to test comfort and fit (Fig. 22). The model provided a stable custom fit, requiring very little adjustment. The uniqueness of ear shape allows for instinctive placement of the device.

Fig. 23 Exploded view of the final concept

Fig. 24 Example of a custom faceplate

Fig. 25 Helix Hearing Aid final concept image

To facilitate fabrication, the concept consists of three main components (Fig. 23). The customizable ear piece that is formed by performing a boolean difference of the helix would be rapid prototyped. The body of the hearing aid would consist of a standard housing that would require less customization to ensure consistency of component assembly. The third part is a customizable rapid prototyped faceplate that can incorporate a variety of patterns or logos based on user preference (Fig. 24).


Fig. 26 Eames leg splint

TailorMade Prosthetic Leg

The final design was largely inspired by a TED (Technology, Entertainment, Design) conference presentation by Aimee Mullins. In the presentation, Mullins describes her experiences as a double amputee attempting to change the identity and perceptions of disability. Mullins encourages creative minds to see prosthetics as an opportunity to explore new potential, blending science and art to spark conversations. The use of visual poetry to transform objects that may be feared and misunderstood into artifacts that create intrigue and understanding is entirely plausible. Mullins encourages the shift from mimicry to replace what was lost, to imagining new symbols that enable

Fig. 27 Hawley's prosthetic leg concept

wearers to become empowered architects of their own identities.

This sense of exploration resonates through two prosthetic leg projects that range from purely conceptual to readily accessible. A student project from Carnegie Mellon exemplifies the sense of brand identity that can strengthen an object. Designer Joanna Hawley developed a prosthetic leg concept that employs materials and curvature from the iconic Eames DCW (dining chair wood). As Pullin explains, Charles and Ray Eames originally explored the use of bent plywood not for chairs, but for leg splints (Fig. 26). The use of organic plywood shapes created a natural cradle for injured U.S Navy members (xi). Bent plywood allowed for lightweight, yet extremely durable structures that would eventually be incorporated into the Eames' influential furniture designs.

Fig. 28 Bespoke Innovations prosthetic legs

Hawley's prosthetic leg returns the material to the realm of disability, while retaining the mainstream appeal and iconic style of the Eames' design (Fig. 27).

As Pullin describes, the transformation from splints to iconic furniture began with Ray Eames playfully exploring sculptures from spare leg splints. The furniture would eventually evolve by balancing the practicality of the leg splints and the open-minded sculptural expressions (xv).

This sense of balance is apparent in the work of Bespoke Innovations and lead designer Scott Summitt. While searching for prosthetic projects that incorporate digital solutions, the design services offered by Bespoke were discovered (Fig. 28). Fairings are the exterior shells applied to motorcycles and aircrafts that provide the visual form and reduction of drag for the vehicle. Bespoke uses this concept to develop fairings for prosthetic legs to provide individuality and form to the otherwise barren mechanical structure. The fairing is attached to the existing prosthetic at points of contact that do not interfere with the function of the leg. Using a combination of laser scanning, computer-aided design, rapid prototyping and traditional manufacturing, the wearer provides input to express their own style through their prosthetic.

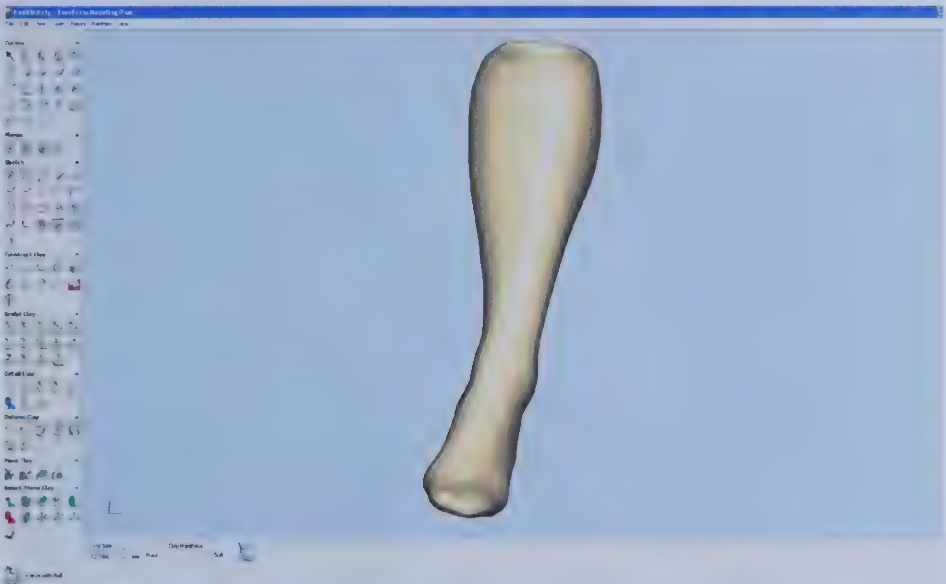

Fig. 29 Using SensAble Freeform to combine and smooth the scanned sections

The intent in developing a new prosthetic leg concept was to combine the whimsical and playful elements expressed in Joanna Hawley's concept with the technical expertise demonstrated by Bespoke Innovations' services.

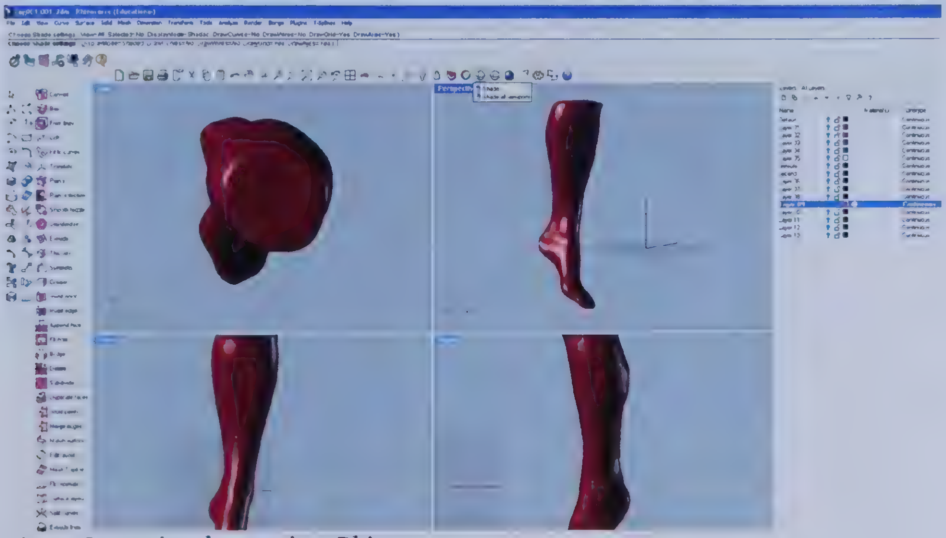

Fig. 30 Importing the scan into Rhino

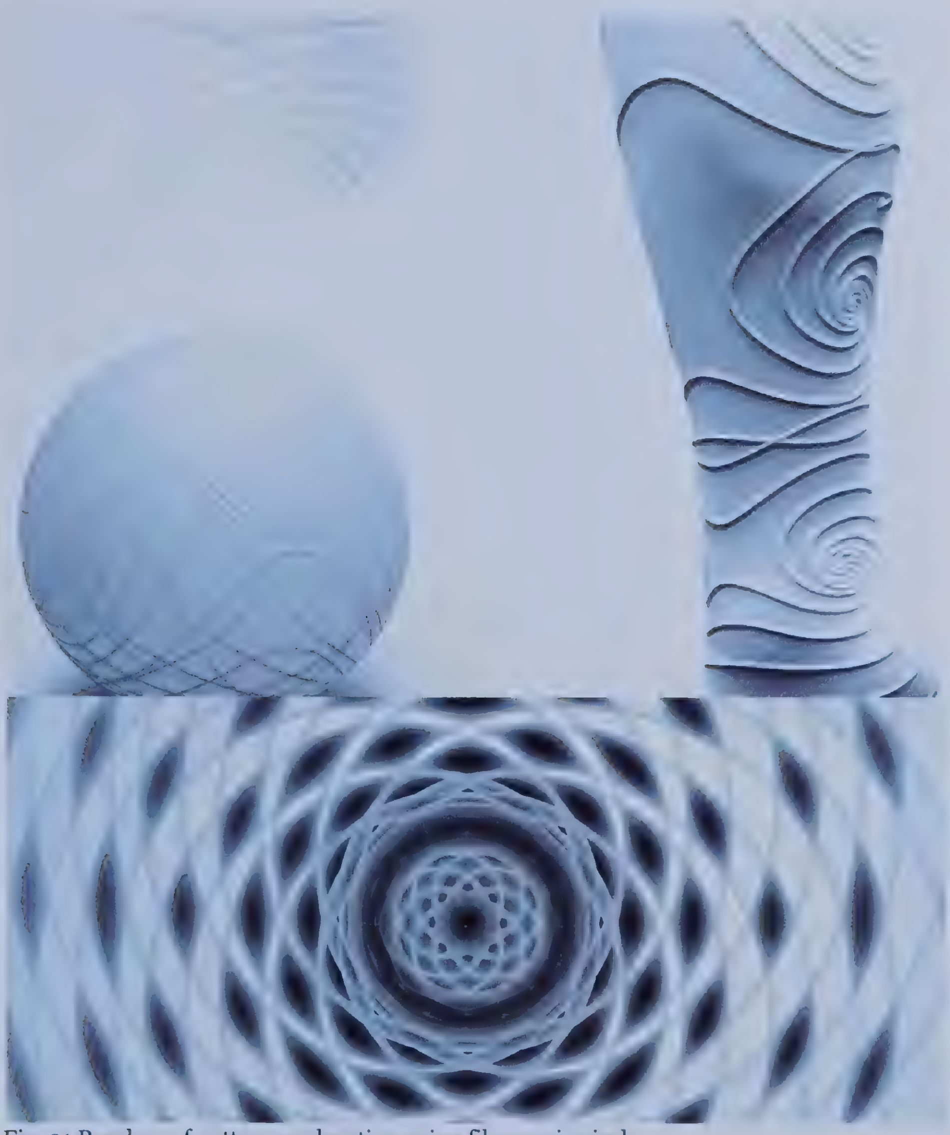

Fig. 31 Renders of pattern exploration using fibonacci spirals

Due to the range required to capture a complete scan of a leg, multiple sections of the author's leg were stitched and smoothed using SensAble Freeform (Fig. 29). If the scanner had a larger scanning range, such as that of 3DMD, the use of Freeform would be eliminated. For the purpose of this concept, the leg is not a completely accurate representation of anatomy as demonstrated in the Dispatch and Helix concepts. This does not inhibit concept generation, but is simply a result of combining multiple scans.

Fig. 32 Renders of concepts exploring geometric exaggerations of muscles

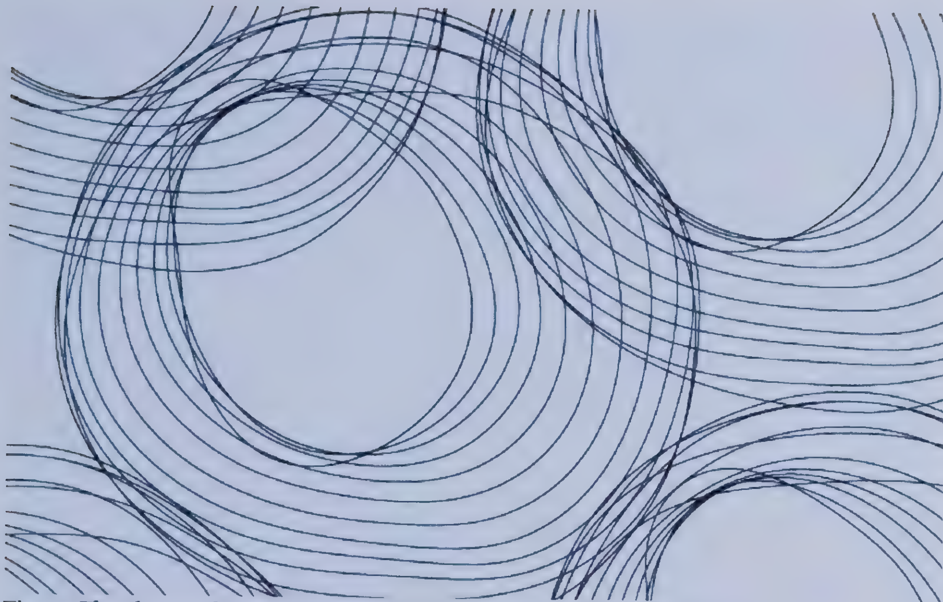

Fig. 33 The clustered pattern derived from an overhead view of the leg

Once the scan was compiled, it was exported as an stl file and imported into Rhinoceros (Fig. 30). Patterns and exaggerations of the natural leg were the main focus of these concepts, using projected patterns based on fibonacci spirals. Connecting arcs that follow the fibonacci sequence (1,1,2,3,5,8,13,21,34 etc) creates geometric patterns that can be projected onto three-dimensional objects (Fig. 31).

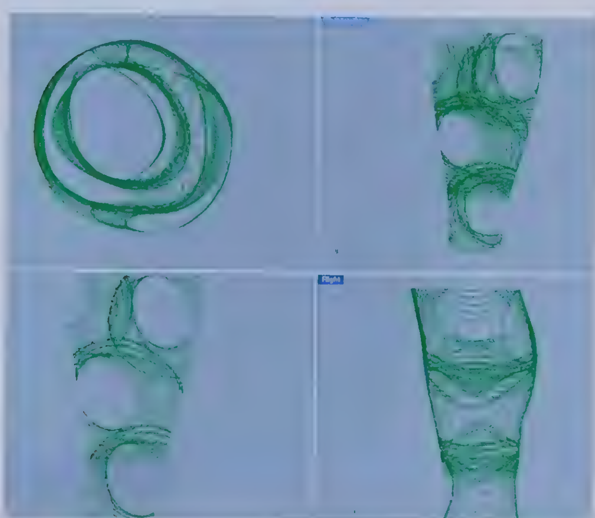

Fig. 34 Projecting the pattern in 3D within Rhino

While modeling the leg, a projected line onto the surface of the 3D scan created a randomized circular pattern. From the top view, this pattern outlining the various

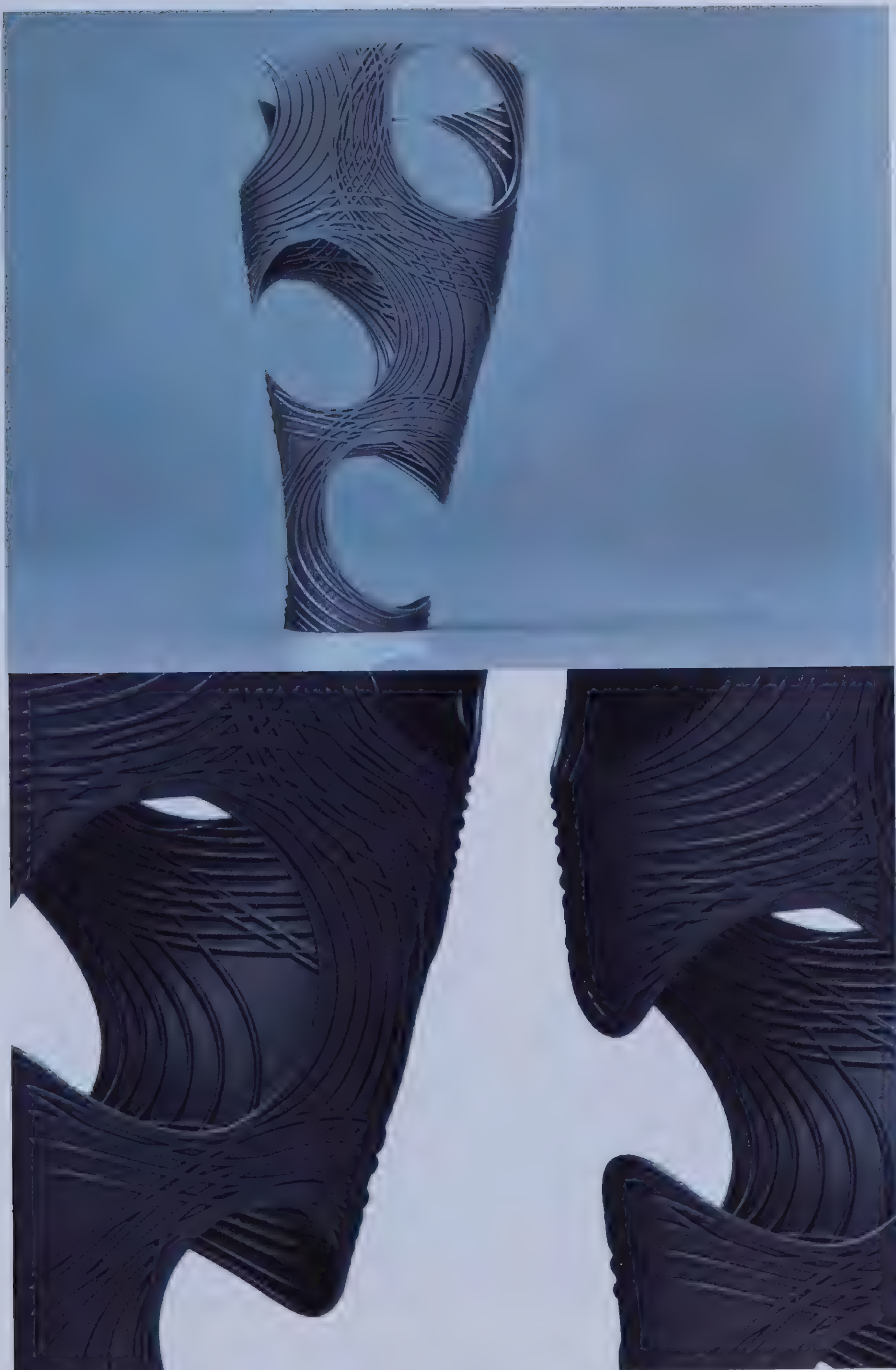

Fig. 35 Renders showing the modeled prosthetic fairing

Fig. 36 The final TailorMade Prosthetic Leg concept attaches to an existing prosthetic leg and offers a unique design that maintains the proportions of the existing limb

layers of the leg emerged (Fig. 33). Upon clustering and projecting the pattern onto the front view of the 3D scan, a new direction began taking shape. Segments of the leg were removed based on intersections of the patterns (Fig. 34). The finished concept represents a play of pattern with negative and positive space exposing elements of the existing prosthetic.

Conclusions

The concepts represent the application of a medical modeling process to three distinct physical artifacts. Each design represents a departure from traditional aesthetics while attempting to emphasize functionality married with fashion. Expanding the approaches to design for disability can potentially elevate these artifacts from their current state of murky mediocrity. Through experimentation and interdisciplinary resources, a shift in perception and purpose can be encouraged. The infusion of meaning beyond functionality is integral to the development of self-expression and confidence for the wearers; incorporating digital processes and rapid prototyping enables new imaginative avenues for exploration not typically seen in the realm of disability. Emotional and social implications are generally secondary to functional considerations, while a healthier balance will likely result in more satisfying and engaging opportunities.

The work presented is intended as a stimulant to entice designers and other potential collaborators to enter the conversation of design for disability. Locally, prototypes of the Dispatch project were selected as part of the Student Design Association's (SDA) 'Out of the Bag' exhibit. The show featured student and alumni work and was displayed at Enterprise Square from October 18-22, 2010. Additionally, the process and three concepts were presented to Robert Lederer and Greig Rasmussen's

Industrial Design 500 course as an introduction to a project entitled the 'Aesthetics of Disability'. Students were charged with designing within the realm of disability to challenge established aesthetics while respecting functional requirements. Projects ranged from a concept for personalized surgical scars to aquatic enhancements for amputees. The diversity and thoughtfulness is encouraging for future projects with undergraduate students, as well as potentially reflective of a growing interest in the health realm.

In order to reach an audience outside of Edmonton, images of the designs were posted on Coroflot, which is a website for creative professional and student portfolios. Coroflot is an open site that enables connectivity across a diverse segment of the creative community with a user base of over 150,000. An initial set of images of the Dispatch project were posted on October 21 2010, and within 24 hours one of the images was chosen to be featured in the site's member gallery. As an email from Coroflot explains: "Everyday thousands of new images get uploaded to Coroflot, and only a handful are featured, so it's kind of a big deal. Keep the great work coming!". Being featured increases viewer traffic, and within the first forty-eight hours, the Dispatch set had accumulated 1019 views and ten likeys. As the help section details, likeys are a voting and image bookmarking system that allow users to indicate his or her favorite work. When an image is 'likey'd', it is saved into the individual's personal 'likebox', which is displayed on their profile. This serves as a public gallery for other Coroflot users to browse interests and discover new work, essentially serving as an image based recommendation. Subsequently posting images for the other two projects has led to over 12,000 image views from October 21-November 18, 2010, with an abundance of positive comments and likeys. In addition, Scott Summitt of Bespoke Innovations, whose work is seen in Fig. 28, sent a complimentary message in regards to the work

along with an open invitation to visit his San Francisco studio to discuss potential collaborations. This initial influx of traffic and responses represents an optimistic inception to what will hopefully transform into a lengthy conversation.

Due to the malleable nature of this design process and relative low cost of developing concepts, further iterations and refinement can be explored with regards to the three projects presented, as well as those that were initially filtered. A medical modeling approach diverts traditional constraints and enables customizable solutions that better reflect individual factors, both functional and emotional. The manner in which other members of society perceive us can instigate insecurities and anxiety, but if there is some measure of control, feelings of devaluation can be replaced by confidence.

The exploration and application of digital technologies facilitates the ability for individuals to exude this confidence through personalized representation. A customizable workflow influenced by the principles of medical modeling presents a new avenue of exploration for designers, while enabling wearers to participate in the re-imagination of their defining accessories. The opportunity to create designs for disability that elicit intrigue and desire requires the injection of creative capital, which will potentially emanate from student participation and evolve into professional careers. A cross-section of designers that are capable of channeling influences from fashion to engineering can breathe life into what is currently stagnant and mundane. With interdisciplinary partnerships, the possibility to augment the current state of artifacts related to disability is imminent. By removing the disguise of disability, the potential to reveal a profound shift that elevates both design and disability is within prosthetic arm's reach.

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Appendix I

During the research, several interviews were conducted with health care professionals to provide context for the author. Staff from the Institute for Reconstructive Sciences in Medicine (iRSM) and the Stollery Children's Hospital were consulted for their expertise in regards to both the functional and emotional considerations related to health, disability and identity. Direct access to health professionals can be elusive; fortunately the author's working relationship with iRSM provides entry to conversations and situations that provide clarity and provoke new ideas. Designs for children with ailments often include more imaginative and playful idea generation, thus consulting the Stollery seemed like a logical progression. Many conversations simply arose due to working relationships with individuals from both of these facilities, and these conversations led to recommendations of patients that would be appropriate candidates to discuss these issues of health, disability and identity. Engaging with patients is both rewarding and precarious, as it is paramount to ensure the patients that are interviewed understand that ideas being discussed are not readily available. The input from the clinical professionals in selecting patients was of great importance, as the intention was not to disrupt the current treatment plan by introducing concepts that would create unrealistic expectations. These meetings are integral to facilitating empathy and understanding, while revealing key latent emotions and themes that act as a springboard for idea generation.

Chronological list of relevant patient interviews with observations:

Patient 1. March 3, 2009. The patient required a bone conduction hearing aid, but continually misplaced the device. The patient conveyed that he was embarrassed to wear the aid, but required it for certain situations, particularly for work. The continuous misplacement and general attitude

towards the device seemed to reflect the patient's detached emotional connection, even though the device provided improved hearing.

Patient 2. March 23, 2009. The patient required a prosthetic ear. This individual worked in a professional office environment, and enjoyed the mimicry aspect of the prosthetic, as it alleviated any initial awkwardness. The patient explained that once he was more familiar with an individual, he would be open to explaining the prosthetic, but it did not have to be a point of conversation unless he introduced the topic. This individual exuded confidence, but the disguise of the prosthetic allowed for some measure of control of the physical representation he conveyed to other people.

Patient 3. March 23, 2009. This patient had oral cancer, and required surgery to reconstruct his tongue. This necessitated a large vertical scar along his chin. This individual viewed this scar as a symbol of recovery and used it as a conversation starter to discuss his battle with cancer.

Patient 4. March 27, 2009. This patient required a bone conduction hearing aid, but valued the device for the enhancements it provided for social situations as well as facilitating communication at her place of employment. The patient initially explained she did not mind the appearance of the device, but also emphasized that she enjoyed being able to conceal it with her hair. She was openly excited about the potential to customize a hearing device, similar to the notion of interchangeable casings found in electronic products such as iPods.

Patient 5. April 3, 2009. The third bone conduction hearing patient recently acquired the device, and was enamored with the improved

hearing it provided. She was ecstatic with the function, and disregarded the appearance of the device due to the ability to conceal it with hair.

Patient 6. July 10, 2009. Meeting with the mother of a pediatric patient. The patient required an external device to regulate heart function, as well as the need for an intravenous (IV) pole when moving around the hospital. Discussions revolved around the challenge of ensuring playfulness was encouraged in the face of health challenges. The mother emphasized the need to maintain a positive outlook by surrounding her child with emotional stability as well as tangible artifacts related to family such as pictures, cards and letters. Being able to customize the physical environment with symbolic objects and keepsakes was key to projecting some degree of normalcy. This provided some measure of control in an unfamiliar and stressful environment.

Patient 7. January 4, 2010. Meeting with patient requiring heart transplant. The patient explained the feeling of being tethered to an IV pole, and how the device becomes an extension of the individual. The ability to incorporate elements for personalized use, such as a space to place a book, drink or sentimental items was discussed. The mechanical aesthetics of most health-related equipment was suggested as challenging the humanness of individuals and further complicating the emotions of encountering such a disruptive time in their lives.

Patient 8. January 14, 2010. The patient had cancer in the orbital region, requiring the removal of an eye. While waiting for the creation of a prosthetic eye, the individual wore fabric pads maintained in place by an adhesive tape. This was changed daily, as these pads are intended for one-time use only. The patient described an interest in having an alternative that could be re-used, but one that did not convey the pirate connotations

associated with eye patches. The ability to have input in the design of this object was discussed, with particular interest in having multiple variations depending on whether the individual was at work or at a social event.

Patient 8. Interview 2. March 17, 2010. Initial renders of designs and an explanation of the process was discussed. The patient demonstrated a high level of interest in being able to personalize a design and achieve a custom fit based on a 3D scan. Although the individual was excited for his prosthetic eye, the desire to have options depending on activity seemed to be of great value. Practical elements such as the ability to interchange sunglass lenses with prescription lenses was emphasized by the patient.

Patient 7. Interview 2. March 19, 2010. Initial renders of designs and an explanation of the process was discussed. The patient was intrigued by the potential to incorporate personal fashion to streamline an individual's 'look'. He remarked that this would be a big departure from what is currently available.

Patient 9. November 10, 2010. This patient required both a prosthetic ear and a hearing device. Discussions of feeling out of place as a child and teenager were initiated by the patient. He explained the progression of being proud of his differences, and how a customizable alternative could empower individuals to discuss their differences instead of hiding them. Controlling the appearance of a device would enable wearers to talk about their differences at a level personalized to the wearer. Depending on the personality, a device could be visually boisterous or more subdued, thus initiating more open discussions regarding disability and identity.

Ben King, IDSA

Work experience

2007-present	iRSM (Institute for Reconstructive Sciences in Medicine) Industrial Designer for the Medical Modeling Research Laboratory
2006-present	Freelance Design Product concept development and visualization

Education

2008-2011	Master of Design (Industrial Design)	University of Alberta
2002-2006	Bachelor of Design (Industrial Design)	University of Alberta
1999-2001	Bachelor of Arts (Political Science and English)	University of Alberta
1998-99	Canadian College Italy	Lanciano, Italy

Teaching and workshop experience

2010	Workshop Instructor: 3D Modeling-Custom Prosthetic Implant Design Hands-on workshop for surgeons demonstrating a digital workflow for the development of facial and orthopedic implants due to cancer or trauma (December 2010)
2010	Workshop Organizer: Functional Head and Neck Reconstruction Hands-on workshop for surgeons using a surgical simulation model to practice reconstruction techniques (April 2010)
2010	Workshop Instructor: Digital Design in Facial Prosthetics (April 2010) Hands-on workshop for Anaplastologists, demonstrating a digital workflow utilizing rapid prototyping to develop facial prosthetics (April 2010)
2010	Practicum Instructor: Design 402 Medical product design (Winter 2010)
2010	Workshop Instructor: Fundamentals in Medical Modeling for Surgery Residents Hands-on workshop for surgery residents demonstrating the basics of medical data acquisition, manipulation and output for medical modeling techniques (May 2010)
2009	Workshop Instructor: Fundamentals in Medical Modeling for Surgery Residents (October 2009)
2009	Workshop Instructor: Fundamentals in Medical Modeling Hands-on workshop for medical professionals demonstrating the basics of medical data acquisition, manipulation and output for medical modeling techniques (June 2009)
2009-present	Seminar Instructor: Master of Surgical Design and Simulation (Rehabilitation Medicine)
2008-2010	Practicum Instructor: Design 586 Practicum in Industrial Design
2008	Teaching Assistant: Industrial Design 502/Mechanical Engineering 460 (Product Design Applications and Technologies)

Recent Media and Presentations

Oct 2010	'Out of the Bag' Exhibit Medical models and product design work featured in this exhibit by the SDA (Student Design Association) and MADE (Media, Art, Design, Exposed in Edmonton).
Aug 2010	Rotary Club of Edmonton Mayfield Invited Speaker
Jul 2010	Design Research Society (DRS) conference Presentation and associated paper titled 'Transformative Design: From Consultant to Clinician' at the Design Research Society (DRS) conference proceedings in Montreal, Quebec. Co-authors- Robert Lederer and Heather Logan.
Apr 2010	Wired Campus Alberta Virtual conference presentation to several junior high schools regarding Computer-Aided-Design and facial prosthetics.
Mar 2010	World Class Health Facilities in Alberta Featured in a promotional video for Alberta Employment and Immigration
Nov 2009	AAMP (American Academy of Maxillofacial Prosthetics) Invited Speaker
Apr 2009	Sanofi Aventis BioTech Challenge Keynote Speaker (with Myka Osinchuk)
Apr 2009	Research and Innovation presentation at the University of Alberta Presentation demonstrated concepts for new Bone Anchored Hearing Aids
Feb 2009	Presenter at Edmonton Pecha Kucha Night
Feb 2009	Global TV: Breakfast Television Featured in segment regarding Design and Medicine
Feb 2009	University of Alberta Senate Presentation One of two UofA graduate students invited by the FGSR to present their work
Jan 2009	Display Canadian Design Magazine Article "Comfort Zone: Adventures of an Industrial Designer in Medicine"
Nov 2008	Global Television: Health Matters Featured in segment regarding reconstructive medicine and digital technology


Ben King
Master of Design